The Same Late-Arriving Wave Both Breaks a Signal and Supports It

— The coherence bandwidth for a delay spread of $1\ \mu$s comes in two conventions: 0.159155 MHz from $1/(2\pi\tau)$ and 0.200000 MHz from $1/(5\tau)$, a ratio of 1.256637, which is $2\pi/5$ — the separator is whether the late arrivals can be resolved and added — [Paper 707]

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— *From thinking to syncing.* —

Abstract

A wave arriving late after bouncing off a wall is treated as a nuisance that breaks the signal. But resolved and added, the same wave becomes a gain.Where the same quantity changes sign is counted here in bandwidth and in decibels.No new theorem or law is claimed. First, even the boundary comes in two conventions——for a delay spread of 1 μs the coherence bandwidth is 0.159155 MHz by one and 0.200000 MHz by the other, a ratio of 1.256637 (Section 2). **Second, widening the band changes what the same late arrival does——one resolvable path at 0.05 MHz, two at 1.2288 MHz and eleven at 10 MHz** (Section 2). **Third, a wide band is itself a gain——a chip rate of 1.2288 MHz against a data rate of 9.6 kbps gives a spreading gain of 128.000000, that is 21.072100 dB** (Section 2). **Fourth, and this is the core. One extra path removes an order of margin——the margin needed for an outage of 0.01 is 20.000000 dB with one path and 8.494850 dB with two** (Section 3). **Fifth, the difference is 11.505150 dB——the same late arrival breaks the signal if it cannot be resolved and gives 11.505150 dB if it can** (Section 3). **Sixth, the separator is whether the late arrivals can be resolved and added——nothing changes on the side of the wave; only whether the receiver can separate it** (Section 4). **Keywords**: fading, coherence bandwidth, resolvable paths, spreading gain, diversity combining, nuisance as resource.

Scope of this paper (scope note): No new theorem or law is claimed——coherence bandwidth, frequency-selective fading, spreading gain and the improvement from combining paths are all standard (Proakis and Salehi 2007, Rappaport 2002).No system is designed——modulation, code design and multiple-access capacity are not treated.The channel is simplified——Rayleigh paths and maximal-ratio combining are assumed; correlation between paths and implementation losses are left out.The figures are not claimed——a delay spread of $1\ \mu$s, a chip rate of 1.2288 MHz and a data rate of 9.6 kbps are all representative.No real system is evaluated——nothing is said about the performance of any particular communication standard.Relation to earlier papers: Paper 687 showed that the one word “resonance” names both the places that expel bodies and the places that protect them, taking the condition that separates them as given——there the point was carried as far as one ratio having opposite consequences. Here, for a phenomenon of the same kind, the separating condition itself is put into numbers: how many paths can be resolved, and how many decibels that is worth.What is added is showing the coherence bandwidth to carry two conventions with a ratio of $\mathbf{1.256637}$, tabulating resolvable paths against bandwidth, putting the spreading gain at $\mathbf{21.072100}$ dB, obtaining the margin for each number of paths and the $\mathbf{11.505150}$ dB between one and two, and placing the separator on whether the late arrivals can be resolved and added.

1. Notation and the Question

Setting: a wave reflected from a wall arrives later than the direct one. Call the spread of those delays τ. With a signal bandwidth B, the number of resolvable paths is of order τB.

$$B_c \approx \frac{1}{2\pi\tau} \ \text{or} \ \frac{1}{5\tau}, \qquad L \approx \lfloor \tau B \rfloor + 1, \qquad G = \frac{B_{\text{chip}}}{R}$$

Call B_c the coherence bandwidth, L the number of resolvable paths and G the spreading gain. Take $\tau = 1\ \mu$s.

Question: is a late arrival a nuisance or a resource?

2. Even the Boundary Comes in Two Conventions

Computation 2.1: for a delay spread of $1\ \mu$s the coherence bandwidth is 0.159155 MHz by $1/(2\pi\tau)$ and 0.200000 MHz by $1/(5\tau)$; the ratio is 1.256637, which is $2\pi/5$.

Observation 2.2

the boundary itself moves by 1.256637 with the convention.Both are rules of thumb for the width over which correlation falls away, and they differ in where “fallen” is taken to be——whoever quotes the boundary must say which convention.

Computation 2.3: **for each bandwidth, the kind of fading and the number of resolvable paths were derived.**

bandwidth	fading	resolvable paths
0.0500 MHz	flat	**1**
1.2288 MHz	frequency-selective	**2**
10.0000 MHz	frequency-selective	**11**

> **Observation 2.4**
>
> **widening the band carries two meanings at once.Kept narrow, the fading is flat and a deep fade leaves nowhere to go. Widened, it becomes frequency-selective: the waveform is distorted, and the paths become separable——one action creates a weakness on one side and a resource on the other.**

Computation 2.5: **a chip rate of 1.2288 MHz against a data rate of 9.6 kbps gives a spreading gain of 128.000000, that is 21.072100 dB.**

3. One Extra Path Removes an Order

Computation 3.1: **for Rayleigh paths combined by maximal ratio, the margin in mean SNR needed for an outage of 0.01 was derived for each number of paths.**

paths	margin required
1	**20.000000** dB
2	**8.494850** dB
3	**4.072829** dB
4	**1.549472** dB

Observation 3.2

this is the core: going from one path to two removes 11.505150 dB.The power, the distance and the noise are the same; what changed is only whether the late arrival was resolved and added——the nuisance has become the resource.

Observation 3.3

the first extra path is worth the most.From one to two, 11.505150 dB; from two to three, 4.422021 dB; from three to four, 2.523357 dB——securing a second path matters more than gathering many.

Observation 3.4

what the 20.000000 dB at one path means.Even where the mean suffices, one time in a hundred the level falls to a hundredth, so a hundredfold margin must be carried——on a single path one designs for the worst case, not the mean.

Observation 3.5

so the band is widened for two reasons.One is the spreading gain of 21.072100 dB; the other is making the paths separable——both follow from “a wide band”, and the mechanisms at work are different.

4. The Separator

Observation 4.1

the separator is whether the late arrivals can be resolved and added.Nothing changes on the side of the wave: the same signal bounces off the same wall and arrives after the same delay——only the bandwidth and the processing of the receiver change, and that alone flips the sign.

Observation 4.2

beside Paper 687.Paper 687 showed the one word “resonance” naming both the places that expel and the places that protect, taking the separating condition as given——there the point reached as far as one ratio having opposite consequences. Here the separating condition itself is given a number, and 11.505150 dB is the size of that difference in sign.

Observation 4.3

what is not said.No system is designed, no real performance is treated, and the channel is simplified to Rayleigh paths with maximal-ratio combining——what is shown is where the same late arrival changes sign, and by how much.

5. Roll Call and Closing

1. **0.159155 MHz by $1/(2\pi\tau)$** (Computation 2.1): **the first convention.**
2. **0.200000 MHz by $1/(5\tau)$** (Computation 2.1): **the second.**
3. **a ratio of 1.256637** (Computation 2.1): **even the boundary is not one.**
4. **two paths at 1.2288 MHz** (Computation 2.3): **resolvable.**
5. **eleven at 10 MHz** (Computation 2.3): **more with more band.**
6. **spreading gain 21.072100 dB** (Computation 2.5): **the wide band itself.**
7. **20.000000 dB with one path** (Computation 3.1): **designed for the worst.**
8. **8.494850 dB with two** (Computation 3.1): **the core.**
9. **a difference of 11.505150 dB** (Observation 3.2): **nuisance into resource.**
10. **resolved and added** (Observation 4.1): **the separator; Paper 687.**

Closing: **The same late-arriving wave both breaks a signal and supports it.Even the boundary comes in two conventions: for a delay spread of 1 μs the coherence bandwidth is 0.159155 MHz or 0.200000 MHz, a ratio of 1.256637——whoever quotes the boundary must say which convention.Widening the band takes the resolvable paths from one at 0.05 MHz to two at 1.2288 MHz and eleven at 10 MHz.And the margin needed for an outage of 0.01 falls from 20.000000 dB with one path to 8.494850 dB with two: one extra path removes 11.505150 dB——the power, the distance and the noise are the same, and what changed is only whether the late arrival was resolved and added.A wide band carries a further 21.072100 dB of spreading gain, by a different mechanism.The separator is whether the late arrivals can be resolved and added.Placed among the earlier papers——Paper 687 showed one ratio having**

opposite consequences and took the separating condition as given; here that condition is given the number 11.505150 dB.To be honest——no system is designed and the channel is simplified to Rayleigh paths with maximal-ratio combining.

References

1. Proakis, J. G., & Salehi, M. (2007). *Digital Communications*. McGraw-Hill.
2. Rappaport, T. S. (2002). *Wireless Communications: Principles and Practice*. Prentice Hall.
3. Yamagishi, Y. (2026). *One Word, "Resonance", Names Both the Places That Expel Bodies and the Places That Protect Them* [Paper 687]. Zenodo. 10.5281/zenodo.23014828

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